EFFECT OF SOIL TYPE AND LEVEL OF SEISMICITY ON SEISMIC DESIGN OF REINFORCED CONCRETE SCHOOL BUILDING

HANIS ATHIRAH BINTI ROSLAN

B. ENG(HONS.) CIVIL ENGINEERING

UNIVERSITI MALAYSIA PAHANG

SUPERVISOR'S DECLARATION

I/We* hereby declare that I/We* have checked this thesis/project* and in my/our* opinion, this thesis/project* is adequate in terms of scope and quality for the award of the Bachelor Degree of Civil Engineering

____

(Supervisor's Signature)

Full Name : DR MOHD IRWAN BIN ADIYANTO

Position : SENIOR LECTURER

Date : 29 MAY 2019

____

(Co-supervisor's Signature)

Full Name : DR. NURUL NADRAH AQILAH BINTI TUKIMAT

Position : HEAD OF COORDINATOR

Date : 29 MAY 2019

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

____

(Student's Signature)

Full Name : HANIS ATHIRAH BINTI ROSLAN

ID Number : AA15140

Date : 29 May 2019

EFFECT OF SOIL TYPE AND LEVEL OF SEISMICITY ON SEISMIC DESIGN OF REINFORCED CONCRETE SCHOOL BUILDING

HANIS ATHIRAH BINTI ROSLAN

Thesis submitted in partial fulfillment of the requirements
for the award of the
B. Eng (Hons.) Civil Engineering

Faculty of Civil Engineering & Earth Resources
UNIVERSITI MALAYSIA PAHANG

MAY 2019

ACKNOWLEDGEMENTS

For the sake of Allah, the Most Gracious and the Most Merciful, Alhamdulillah, all gestures of recognition to Allah for the qualities and His blessing in completing this thesis. Praise and peace be upon Prophet Muhammad S.A.W, his family and his companion.

This thesis would not have been possible without help, support and patience of my supervisor, Dr. Mohd Irwan Bin Adiyanto, not to mention his advice, and valuable guidance regarding earthquake knowledge. Thank you and deepest appreciation on the completion of my thesis. Apart from that, my appreciation also goes to our Faculty of Civil Engineering's Head of Coordinator for final year project, Dr. Nurul Nadrah Aqilah Binti Tukimat for assistance in preparing this thesis.

I am most grateful to my colleagues, Anis Farhana Binti Mazlan, Azlina Binti Nordin, Nur Izzati Aliah Binti Azman, Nur Hazwani Binti Mohd Rashid and Ummu Nurulatiqah Binti Kamis who have given me their unequivocal guidance and support throughout, as always, for which my mere expression of thanks likewise does not suffice.

Above all, I would like to thank my parent, Roslan Bin Hashim and Azlina Binti Abdul Aziz for their personal support and great patience at all times. Not to forget, deepest thanks to my siblings who have given support throughout the completion of this thesis.

ABSTRAK

Pertimbangan seismik tidak diambil kira untuk reka bentuk dan pembinaan di Malaysia. tetapi selepas insiden berlaku pada 5 Jun 2015, gempa bumi 6.0 magnitud telah berlaku di Ranau, Sabah, yang berlangsung selama 30 saat. Selepas kejadian itu, pihak berkuasa tempatan mula mempertimbangkan semula untuk melaksanakan reka bentuk seismik terutama bangunan sekolah. Di Malaysia, bangunan sekolah konkrit bertetulang (RC) akan menjadi tempat tumpuan perlindungan utama masyarakat apabila berlakunya bencana alam untuk kekal sehingga bencana berkurangan. Oleh itu, ianya adalah sangat penting untuk memastikan reka bentuk bangunan sekolah RC pada masa akan datang dapat menampung beban dari gempa bumi, yang bermaksud bahawa bangunan sekolah RC tetap berfungsi walaupun setelah berlakunya gempa bumi. Objektif kajian ini adalah untuk menentukan kesan jenis tanah dan kesan tahap seismicity pada jumlah pengukuhan keluli. Penggunaan model untuk kajian ini adalah empat tingkat bangunan sekolah RC yang reka bentuk berdasarkan Eurocode 8. Terdapat sejumlah sepuluh model dengan berbeza jenis tanah dan tahap seismicity. Kemudian, analisis dilakukan kepada semua model dengan menggunakan Designer Struktur Tekla untuk memperoleh kedua-dua objektif tersebut. Maklumat berdasarkan jumlah keluli yang diperlukan boleh didapati dari analisis. Ia diwakili dengan menggunakan graf Spektrum Respon Reka Bentuk dan jadual-jadual yang mengandungi maklumat seperti momen lenturan. Berdasarkan hasilnya, peratusan yang berbeza daripada berat pengukuhan keluli yang diperlukan untuk reka bentuk bukan seismik yang menimbangkan Jenis Tanah meningkat 38%, 92% dan 131% untuk Tanah Jenis A, Tanah Jenis C dan Tanah Jenis E, masing-masing. Oleh itu, dapat disimpulkan bahawa model yang dibina pada Tanah Jenis E memerlukan jumlah pengukuhan keluli yang tinggi dalam setiap $1m^3$ konkrit. Walaupun bagi magnitud PGA yang berlainan, keputusan menunjukkan bahawa perbezaan peratusan pengukuhan keluli yang diperlukan berbanding dengan reka bentuk bukan seismik untuk rasuk dan lajur seluruh bangunan telah meningkat daripada 13%, 66% dan 131% untuk PGA bersamaan dengan 0.04g, 0.07g dan 0.10g masing-masing. Oleh itu, dapat disimpulkan bahawa model yang dibina di atas PGA 0.10g diperlukan jumlah tetulang keluli yang tinggi dalam setiap $1m^3$ konkrit. Oleh itu, jenis tanah dan tahap seismicity perlu diambil kira untuk reka bentuk kerana pembolehubah ini mempengaruhi jumlah keluli yang digunakan.

ABSTRACT

Seismic considerations are not taken into account for design and construction in Malaysia. but after the incident happened on 5th June 2015, earthquake of 6.0 magnitudes had struck in Ranau, Sabah, which lasted for 30 seconds. After the incident happened, the local authority starts to reconsider to implement the seismic design especially school building. In Malaysia, reinforced concrete (RC) school buildings will be the main focus of the community's protection when there is a catastrophic disaster to remain until the disaster is reduced. Therefore, it is very important to ensure that RC school building design in the future will be able to accommodate the burden of the earthquake, which means that the RC school building will work even after the earthquake. The objective of the study is to determine the effect of different Soil Type and effect of Level of Seismicity on the amount of steel reinforcement. The model use for the study is four-storey RC school building which is design based on Eurocode 8. There are total of ten models with different Soil Type and Level of Seismicity. Then, the analysis is conducted to all of the models by using Tekla Structural Designer to obtain both of the objectives. The information based on the amount of steel required is provided from the analysis. It is represented by using Design Response Spectrum graph and tabulated tables that contained information like bending moment. Based on the results, the percentage different of weight of steel reinforcement required for non-seismic design which considering Soil Type is increased 38%, 92% and 131% for Soil Type A, Soil Type C and Soil Type E, respectively. Thus, it can be concluded that model built on Soil Type E required high amount of steel reinforcement per $1m^3$ concrete. While for different magnitude of PGA, the results show that the percentage difference of steel reinforcement required compared to non-seismic design for beam and column of the whole building had increased from 13%, 66% and 131% for PGA equals to 0.04g, 0.07g, and 0.10g respectively. Thus, it can be concluded that model built on PGA of 0.10g required high amount of steel reinforcement per $1m^3$ concrete Therefore, Soil Type and Level of Seismicity should be taken into consideration for design since these variables influence the amount of steel used.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

a_{g}	Design ground acceleration
a_{gR}	Reference peak ground acceleration
$A_{s,prov}$	Total area of steel provided
$A_{s,req}$	Total area of steel required
F_{b}	Base shear force
f_{cd}	Design value of concrete compressive strength
f_{cu}	Characteristic cylinder strength of concrete
F_{i}	Lateral load on storey
$\mathrm{f_y}$	Yield strength of reinforcement
g	Acceleration due to gravity, m/s^2
G_{k}	Dead load
H	Storey height
M	Bending moment
m	mass of structure
M_{Rb}	Design moment resistance of beam
M_{Rc}	Design moment resistance of column
M_{w}	Magnitude of earthquake intensity
N	Number of storey
q	Behaviour factor
Q_{k}	Live load
S	Soil factor
$S_{\mathrm{d}}(T_1)$	Ordinate of the design spectrum at period
T_1	Fundamental period of vibration
T_{B}	Lower limit of the period of the constant spectral acceleration
T_{C}	Lower limit of the period of the constant spectral acceleration
T_{D}	Beginning of the constant displacement response range of the spectrum
V	Beginning of the constant displacement response range of the spectrum

LIST OF ABBREVIATIONS

BS	British Standard
DCH	Ductility Class High
DCL	Ductility Class Low
DCM	Ductility Class Medium
IDR	Interstorey Drift Ratio
JKR	Jabatan Kerja Raya
PGA	Peak Ground Acceleration
RC	Reinforced Concrete

CHAPTER 1

INTRODUCTION

1.1 Background

An earthquake is a phenomenon that is difficult to expect when it will happen. This phenomena happens because of the powerful shaking from the earth's surface. This shaking was caused by movement in the outermost layers of the earth. Figure 1.1 shows the earth's layer which is made of four basic layers which are super-heated core and its thin outer layer the crust, nearly solid bulk mantle, the liquid outer core and solid inner core. Earthquakes are caused by shifts in the outermost layers of earth a region called the lithosphere. An earthquake results from the sudden release of energy stored in the lithosphere by the continuous motion of plates. Litosphere is an uncontinuos piece that wraps around the whole earth. It was actually made up of giant puzzle pieces called tectonic plates.

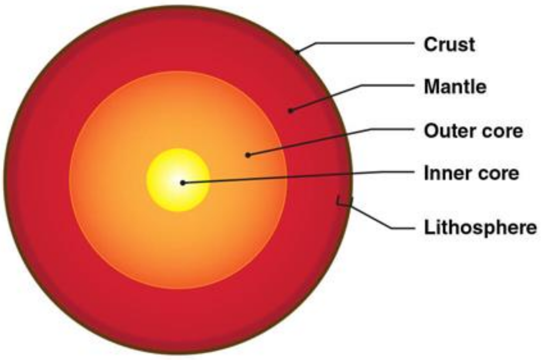

Figure 1.1 A diagram of earth's layers

In Malaysia, the major natural processes that affects its landscapes are flooding, landslides and earthquakes. However, the study on plate tectonics and earthquakes in Malaysia is minimal as the effects are still within the safe zone when compared to the other processes, and countries such as Nepal and Indonesia (Gill et al., 2015). Tectonic plates are constantly shifting as they drift around on the viscous, or slowly flowing, mantle layer below. This non -stop shifting or movements causes stress on earth's crust. When at one point the stresses get too large, it leads to cracks called faults, releasing elastic strain energy stored in the surrounding crust, which then radiates from the fault rupture in the form of seismic waves (Elghazouli, 2009).

Peninsular Malaysia covers an area about 0.3 million km2 at the southern tip of mainland Asia and is connected by land to Thailand to the north while separated from Singapore by Johor Strait to the south and from Sumatra of Indonesia by Malacca Strait to the west. Borneo, which contains the states of Sabah and Sarawak, is located east of Peninsular Malaysia and is separated by South China Sea.

The location of Malaysia is one of the countries that are safe from earthquake as it is located at the equator of the globe which are far away from the active seismic fault zone. Moreover, Malaysia part of the complex Eurasian and Indo-Australian plate tectonics which is located on southern edge of the Eurasian Plate which is known as Sunda Plate as shown in Figure 1.2. As the earthquake happened in Southern Philippine and Sumatera, it triggered several active faults that possible for Malaysia to experienced earthquake. However, as the previous recorded earthquake that occurred in the neighbouring countries such as Thailand and Indonesia, Malaysia is occasionally subjected to tremors. Seismic design for high-rise buildings, bridges and others structure has not been practiced in Malaysia, although Malaysia experiences minor to moderate earthquakes across the country (Ramli et al., 2017). Seismicity within the Sunda Plate has been historically low with progressive collision with the Eurasian Plate relatively slow.

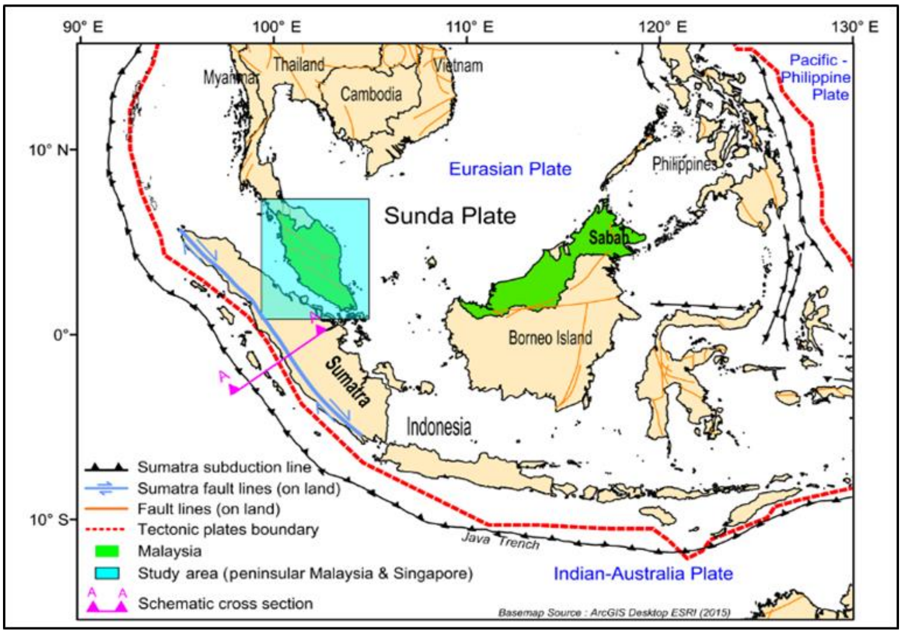

Figure 1.2 Location of Malaysia on the Sunda Plate and the seismic sources around it (modified from Loi et al., 2016). The subduction lines, fault lines and tectonic boundary.

Source: (ArcGIS Desktop ESRI (2015))

During the earthquake, when the seismic waves reach the earth's surfaces it will shake all the structures on the ground to be unstable due to the sudden force resulted from the movement and ground motion caused by earthquake and can lead to destruction. The vibrations caused by the movement of the plates bring bad impacts to the earth surface. Based on our daily life, we can see clearly people may lost their sources of income while wild life lost their habitat. Meanwhile, man-made structures like buildings, bridges, roads and slopes will be affected by this natural disaster. This situation also may contributes to lots of injury and fatality, lost of property, fire, flooding, and the most affliction is it can induce tsunami.

In a conclusion, every structural building is able to withstand seismic action and safe to use. This is a safe step to avoid injuries and fatality caused by earthquake strike. Therefore, the future design of buildings as well as the inspection and assessment of existing buildings shall be designed according by referring to seismic provision code such as Eurocode 8 (2004).

REFERENCES

Adiyanto, M. I., (2016). Influence of Behaviour Factor on Seismic Design and Performance of Reinforced Concrete Moment Resisting Frame in Malaysia, *Universiti Sains Malaysia*. pp 1-240.

Adnan, A.; Hendriyawan.; M.A.; and Selvanayagam, B. (2008). Development of seismic hazard maps of east Malaysia. In: Advances in Earthquake Engineering Application. Penerbit UTM, 1-18.

Ahmad Jani F. (2018). Seismic Design for Reinforced Concrete Hospital Building Influenced by Level of Peak Ground Acceleration and Class of Ductility. *Universiti Malaysia Pahang Thesis.* p.p 34-49.

Alexander, Y., Suratman, S., Liau, A., Hamzah, M., Ramli, M. Y., Ariffin, H., Abd. Manap, M., Mat Taib, M. B., Ali, A. and Tjia, H. D. (2006). Study on the Seismic and Tsunami Hazards and Risks in Malaysia. In: (JMG), M. A. G. D. M. (ed.) Report on the Geological and Seismotectonic Information of Malaysia. Kuala Lumpur: Ministry of Natural Resources and Environment

Earthquake.usgs.gov. (2015). *M 6.0 - 14km WNW of Ranau, Malaysia*. [online] Available at:https://earthquake.usgs.gov/earthquakes/eventpage/us20002m5s#executive [Accessed 11th Feb 2019].

Elghazouli, A. Y. (2009). Seismic design of buildings to Eurocode 8. London and New York, Spon Press, pp. 106-173.

Elnashai, A.S., and Sarno, L.D. (2008). Fundamentals of earthquake engineering. West Sussex, John Wiley & Sons Ltd, pp.97-98.

Eurocode 1, (2002). Actions on Structures, Part 1-1: General Actions, Densities, Self-weight, Imposed Loads for Buildings. The British Standards Institution.

Eurocode 8 (2004) Design of Structures for Earthquake Resistance. Part 1: General rules, seismic actions, European Committee for Standardization.

J.Gill, N.S. Shariff, K.Omar, & Z.M. Amin. (2015). Tectonic motion of Malaysia: Analysis from years 2001 to 2013. *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume II-2/W2.*

Jabatan Kerja Raya Malaysia (2017). Schedules of Rates 2017. PDF file *JKR20800-0209-17*. p.p 13-14.

JMG (Minerals and Geoscience Department), 2006, “Seismotectonic of Malaysia”, Third Edition 2006, Malaysia.

Malaysia National Annex to Eurocode 8 2017 *Design of Structures for Earthquake Resistance Part 1: General Rules, Seismic Actions and Rules for Buildings* (Selangor: Department of Standards Malaysia)

Malaysian Meteorological Department (2009) [Online], [Accessed 2 March 2019]. Available from WorldWide Web: http://www.met.gov.my/

McKenzie, W. M. C. (2004). Design of Structural Elements, 656. New York, Palgrave Macmillan pp.616.

Miska. N. (2015), Cost Implication of Seismic Design of RC Building Based on Indonesian Code and Eurocode 8, *Universiti Sains Malaysia*, Master of Science (Structural Engineering).

MOSTI, (2009), Malaysian Meteorological Service. Seismic and Tsunami Hazards and Risks Study in Malaysia.

Nasai, N. A. B. M. (2017). Effect of soil type on seismic performance of reinforced concrete school building (Doctoral dissertation, Universiti Malaysia Pahang).

Raghunandan, M. and Liel, A.B. (2013). "Effect of ground motion duration on earthquake-induced structural collapse". Structural Safety 41, pp. 119–133.

Ramli M. Z., Adnan A., Kadir M. A. A, Alel M. N. A. (2017), 'Cost Comparison for Non Seismic (EC2) and Seismic (EC8) Design in Different Ductility Class, 'International Journal of Civil Engineering and Geo-Environmental'.

Safie N. J. (2018). Seismic Design of Reinforced Concrete School Building in Sabah affected by Soil Type and Ductility Class. *Universiti Malaysia Pahang Thesis.* p.p 49-66.

Saka S. T. (2018). Effect of Soil Type and Grade of Concrete on Amount of Steel for Reinforced Concrete Hospital Building with Seismic Design. *Universiti Malaysia Pahang Thesis.* p.p 46-63.

Taresh H. M. A. (2010). Seismic Design of Reinforced Concrete School Buildings in Malaysia based on UBC 97 and ACI 95. MSc Dissertation, School of Civil Engineering, *Universiti Sains Malaysia.*

Vickery, D. J. (1982). School Buildings and Natural Disaster. United Nations, Educational, Scientific and Cultural Organization (UNESCO), Paris, pp. 29-33.

Yaakup S. N. (2018), Influence of Concrete Grade and Level of Seismicity on Seismic Design of Reinforced Concrete School Building. *Universiti Malaysia Pahang Thesis.* p.p 32-45.